International Journal of Advance Engineering and Research Development (IJAERD)
Special Issue, Volume 1,Issue 4, April 2014, e-ISSN: 2348 - 4470 , print-ISSN:2348-6406

Image Metamorphosis using Mesh Warping and Field Morphing

Shashank Rana[1], Nikil Patel[2], Mr Vatsal Shah[3]

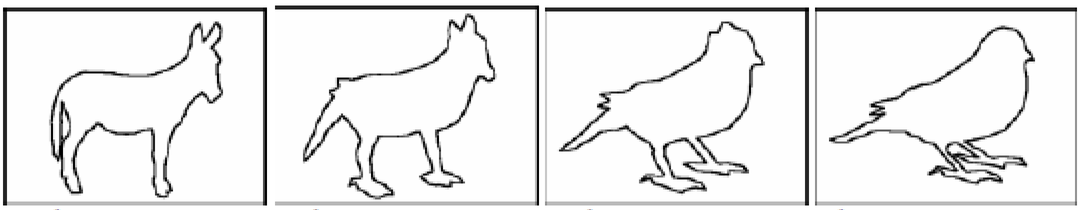
[1]*Information Technology Department, BVM Engineering College, shashankrana29@ymail.com*
[2]*Information Technology Department, BVM Engineering College, patel.nikil1994@gmail.com*
[3]*Assistance Professor, BVM Engineering College, vatsal.shah@bvmengineering.ac.in*

Abstract- This paper gives detailed description mainly on two Image Morphing techniques: Mesh Morphing and Field Morphing with proper comprehensive examples and mathematical explanation as per requirement. This survey describes information about image morphing technique. The metamorphosis technique of images has more captivity in recent years. It is proved that metamorphosis technique is potent in film industry and television picture, smooth transformation of one image into another image through changing pixels location. This paper reviews the information about morphing in terms of areas: Mesh Morphing and Field Morphing.

Keywords—Cross dissolve, Image morphing, mesh morphing, field morphing, Image warping

I. INTRODUCTION

Image morphing is originally known as “Image Metamorphosis”. The word metamorphosis” has its origins in the Greek language. The common meaning of the word in a dictionary is a change in form or nature. In this section we will give several examples of metamorphosis in order to motivate the subject. Image morphing, due to unbounding scope of Image Processing Technology, has been proven a very important application for transforming from one image to another. Besides it has many other applications in films and television industry. Figure 1 shows the basic idea behind Image morphing as it transforms the donkey to bird gradually. The donkey morphed as a bird where there are two intermediate images between donkey and bird. Consider the boundary (vertex and edges) of images. The weight (0.0 to 1.0) is blending that will transform from the source to the target graphical objects. The sum of the weight will be always 1.0.



Donkey w =1.0	Donkey w =0.67	Donkey w =0.33	Donkey w =0.0
Bird w = 0.0	Bird w = 0.33	Bird w = 0.67	Bird w = 1.00

Fig 1 morphing between 2D shapes

Image morphing is the combination of two techniques: image warping followed by color interpolation. A morph is a simultaneous warp of the image shape and a cross-dissolve of the image colors. The cross-dissolve is the easy part; controlling and doing the warp is the hard part. The warp is controlled by defining a correspondence between the two pictures. The correspondence should map eyes to eyes, mouth to mouth, chin to chin, ears to ears, etc., to get the smoothest transformations, for example based on a particular face. [1]

Fig. 2. Cross-dissolve. Image transitions are achieved by linearly interpolating pixel colors to fade from one image to another [1]

Apart in filmmaking, image morphing also had been used in video making since 1985. Godley & Crème, an English rock duo is the first one who introduced the cross-fade morphing effect in their music video, "Cry" .The famous James Cameron's movie, "Terminator", and the Michael Jackson's "Black and White" music video also became very popular because of the implementation of image morphing.

Nowadays, besides applying image morphing in films, television shows, videos, images and video games, image morphing is also implementing in multimedia projects like presentations, education, electronic book illustrations, and computer-based training. It is not only specific to entertainment use.

II. TECHNIQUES FOR ACHIEVING IMAGE MORPHING

In this section, two common and very popular morphing techniques Mesh Morphing and Field Morphing are discussed.

2.1 Mesh Morphing

Intended to attempt of converting the Fin Raziol into human form back, in the movie Willow (1998), in the Lucas' Industrial lights & Magic (ILM) first roots of this algorithm was pioneered by Douglas Smythe and has been successively used in motion picture [1]. The mesh-warping algorithm relates features with non-uniform mesh in the source and destination images, i.e., the images are broken up into small regions that are mapped onto each other for the morph. Here in this technique the feature specification is done by the Rectangular gird (Mesh) which is depicted in figure 3.

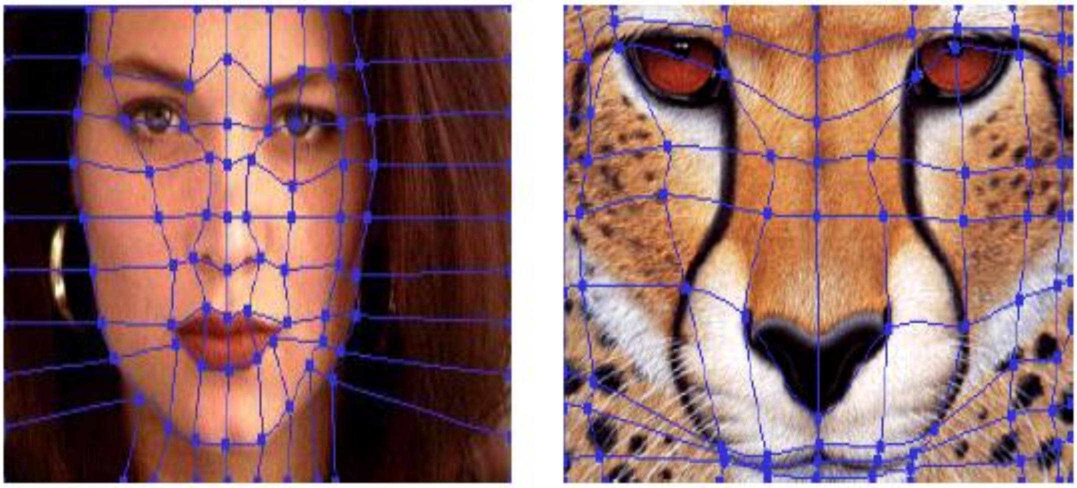


Fig 3 Warping of two images using Rectangular grids (Mesh)

2.1.1 Two Pass Mesh-Warp

In this algorithm, the warping process is done in two ways: Horizontal mesh warping followed by Vertical mesh warping. It performs 2D image warping computation using a combination of two 1D warping computation. Figure 5 shows two-pass algorithm of an image and corresponding meshes of that image.

To illustrate the two-pass mesh warping algorithm, consider the image sequence shown in Fig. 5.The five frames in the middle row represent a metamorphosis (or morph) between the two faces at both ends of the row. Refer these two images as I_S and I_T, the source and the target images, respectively. The source image is associated with mesh M_S. It specifies the coordinates of control points, or landmarks. A second mesh M_T specifies their corresponding positions in the target image. Meshes M_S and M_T are respectively shown overlaid on I_S and I_T in the upper left and lower right images of the figure. Notice that landmarks such as the eyes, nose, and lips lie below the corresponding grid lines in both meshes. Together, M_S and M_T are used to define the spatial transformation that maps all points in I_S onto I_T. The meshes are constrained to be topologically equivalent; i.e.no folding or discontinuities are permitted. Therefore, the nodes in M_T may wander as far from M_S as necessary, as long as they do not cause self-intersection. Furthermore, for simplicity, the meshes are constrained to have frozen borders. All intermediate frames in the morph sequence are the product of a four-step process. In addition to this, Fant's algorithm was used to resample the image in a separable implementation. [4]

for each frame f **do**
  Linearly interpolate mesh M, between M_S and M_T
  Warp I_S to I_1, using meshes M_S and M
  Warp I_T to I_2, using meshes M_T and M
  Linearly interpolate image I_f, between I_1 and I_2
end

Fig 4 Algorithm for two – phase mesh warping [1]

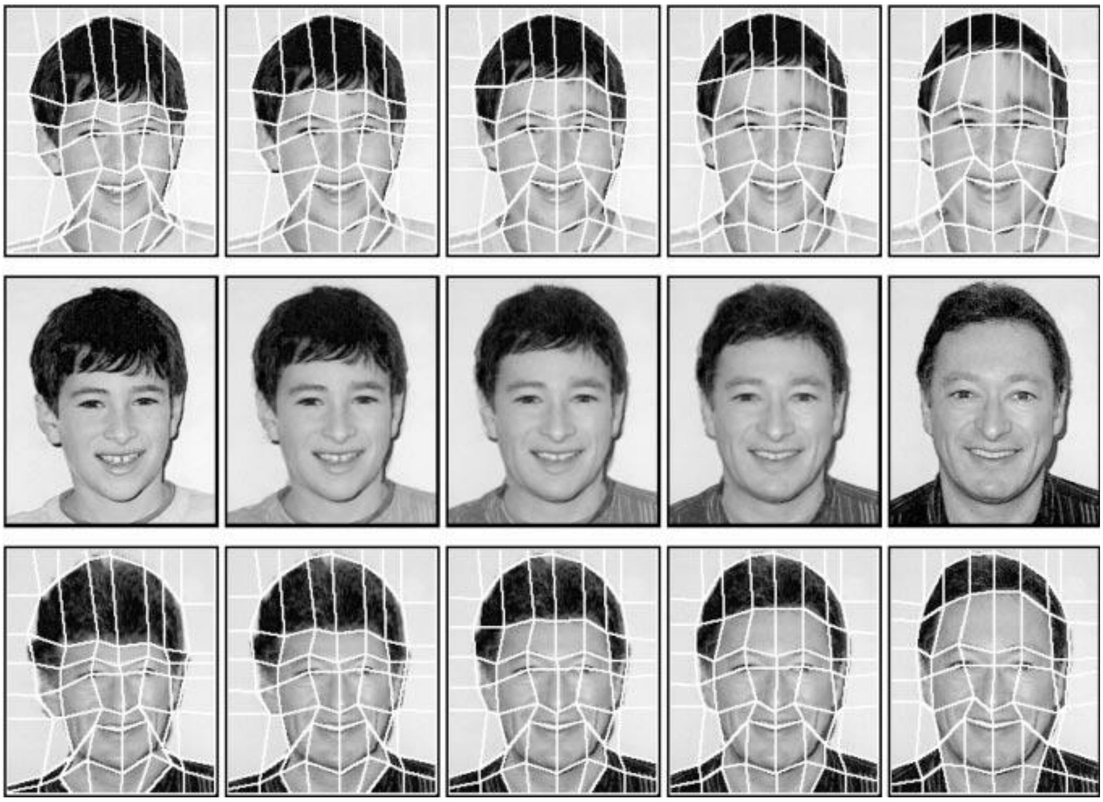


Fig 5 resultant images after warping

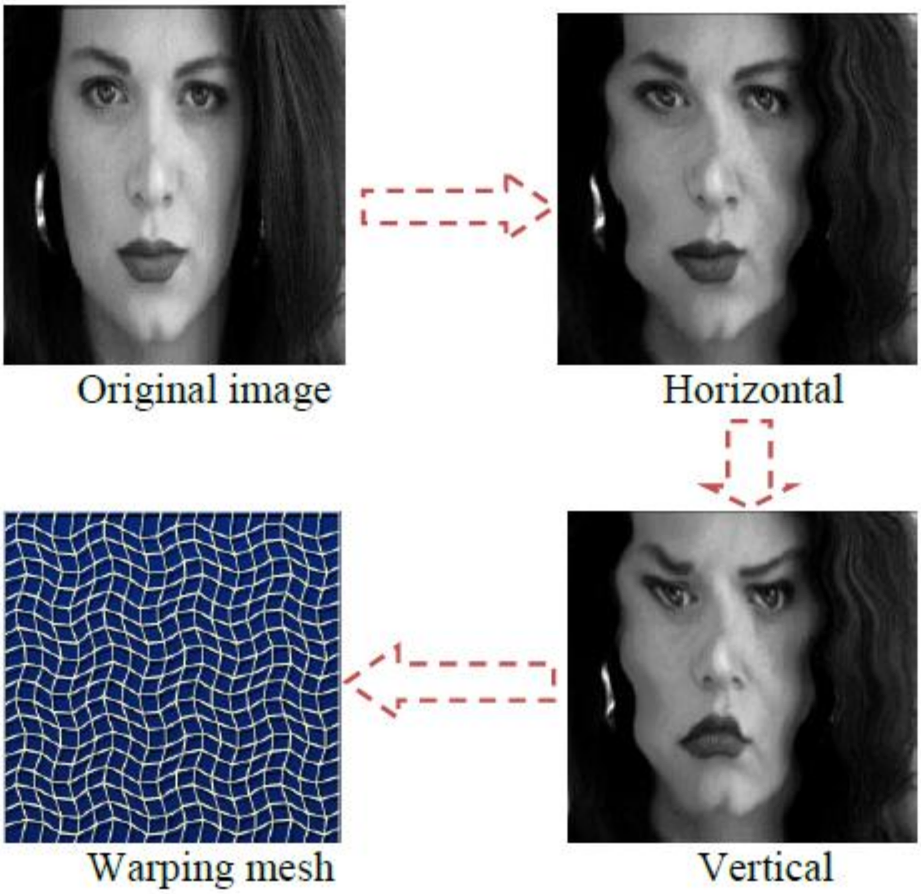


Fig 6 Two-pass warping (Horizontal followed by Vertical) [2]

First pass is horizontal warping of original image to auxiliary image and second pass vertical warping of that auxiliary image is to final warped image. Auxiliary mesh is used to generate auxiliary image. In auxiliary mesh, each mesh point at the auxiliary mesh set the *x* coordinate from the warping mesh and the *y* coordinate from the original mesh. Figure 6 shows horizontal and vertical mesh warping. Here in Horizontal Warping, in this paper only vertical splines of original and auxiliary image is used. In order to maintain one-to-one correspondence, warp each scan line in the original image to the scan line in the auxiliary image independently for vertical splines. They are intersected the scan line and the splines. There is one-to-one correspondence between the splines and also correspondence between intersection points. Practically, such this work can be accomplished by using Catmull-Rom cubic spline to interpolate and map each pixel on the scan-line of the auxiliary image to the pixel on the scan-line in the original image as shown in figure 7

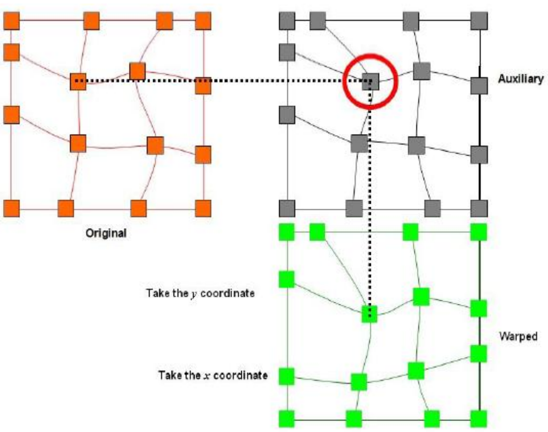


Fig 7 Horizontal and Vertical mapping with Auxiliary Image

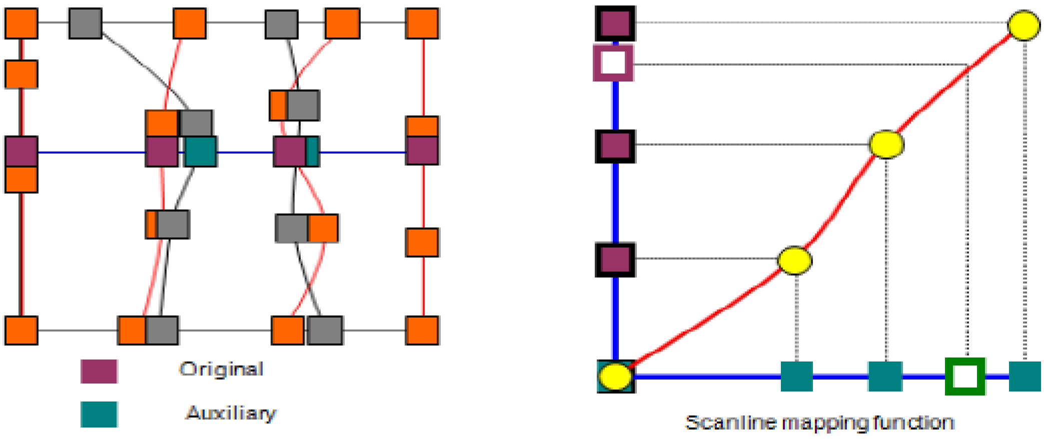


Fig 8 Warping a Scan line [2]

2.1.2 Advantages and drawbacks

The advantages of mesh warping are low computational cost due to use of bi-cubic interpolation only for warping, nevertheless sometimes it is very tedious work to specify the meshes, which is considerable drawback for low computational capable system and where time is a critical factor. In addition to this, it is sometimes cumbersome to use because a control mesh is always required although the structure of the image features may be arbitrary. [4]

2.2 Field Morphing

The field morphing algorithm developed by Beier and Neely [2] at Pacific Data Images grew out of the desire to simplify the user interface to handle correspondence by means of line pairs with arbitrary configurations. For specifying corresponding features, it uses directed line segments as starting and ending points of corresponding line segments corresponds respectively shown in fig 9.

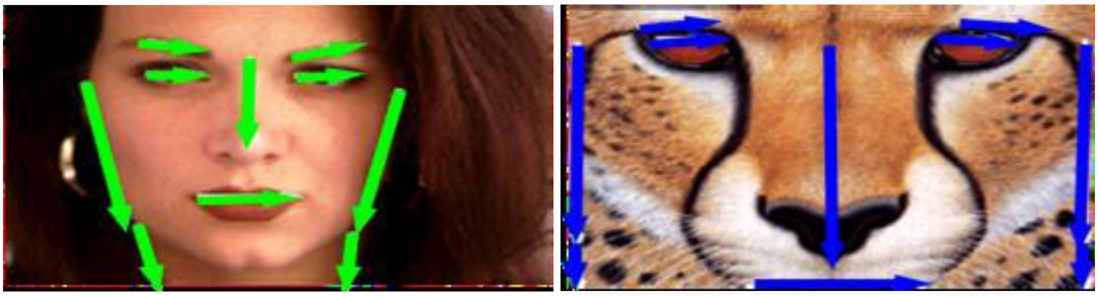


Fig 9 Line segments correspondence in Field morphing

2.2.1 Field Morphing using Line segments

This is one of the most popular and efficient techniques based on Vector algebra. Due to the discrete nature of raster images, one is in no way ensured that each input pixel exactly maps to an output pixel. Consequently warping is mostly performed backwards - i.e. from the output image to the input image. For inverse mapping, every pixel X in the warped image, find its location X' in the original image that described in fig 10. Compute the *(u, v)* coordinates of pixel X with respect to the line segment in the warped image where *u* is the position along the line and *v* is the signed distance from the line. Map *(u, v)* coordinates with respect to the line segment in the original image, resulting in location X'. [2]

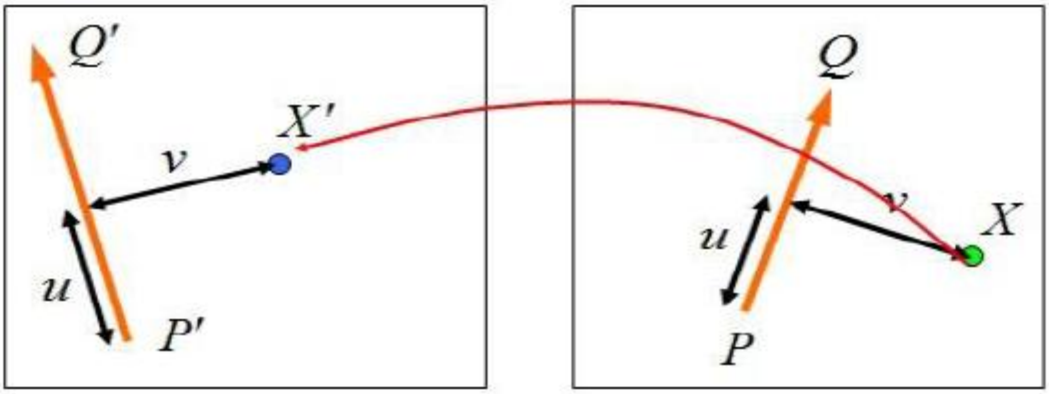


Fig 9 mapping the coordinates in Field warping

The mathematical interpretation of this mapping shown in above fig is as follows: [2]

$$u = \frac{(X-P).(Q-P)}{||Q-P||^2}$$

$$v = \frac{(X-P).Perpendicular(Q-P)}{||Q-P||}$$

$$X' = P' + u.(Q'-P') + \frac{v.Perpendicular(Q'-P')}{||Q'-P'||}$$

Where,

u: position along the line such that u = 0.0 at P and u = 1.0 at Q. Less than 0.0 or greater than 1.0 is outside of consideration according to the figure.

It can be easily proven that any object consisting of the line segments can be warped in one line pair such as translation, rotation and scaling in one direction. Weighted combination of points defined by each pair of corresponding lines. Fig. 11 shows warping with multiple line pair.

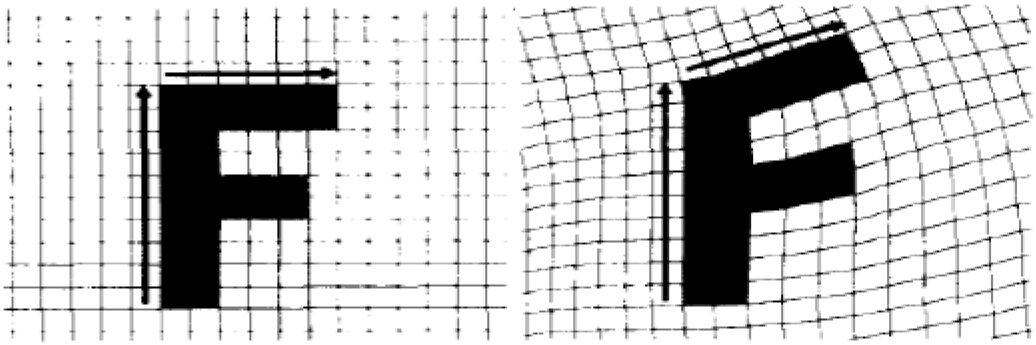
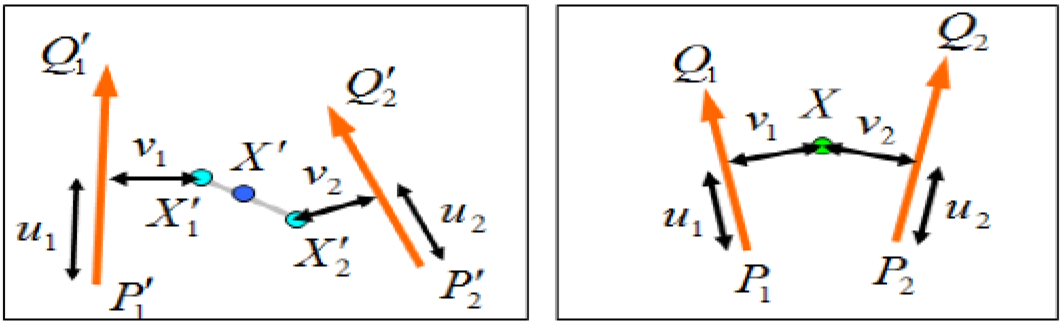


Fig 10 Rotation of mesh



Original ***Warped***

Fig 11 Multiple Line Pair warping

Now the weight of each pair is a function of line length and the distance which can be mathematically described as follows: [2]

$$wieght(i) = \left[\frac{length(i)^p}{a + distance(i)}\right]^b$$

Where,

w (i): weight of the ith line

length (i): length of the ith line

dist (i): distance from X to the ith line

a: mapping of pixels on the line

b: fall off of weight with respect to distance [0.5, 2.0]

p: influence of the length of the line [0.0, 1.0]

2.2.2 Ghost effect

While applying the transformation on the line segments, it is the common issue that line segments would be shrunk, particularly in case of rotation. This is generally known as the”Ghost Effect”. [2]

Fig 11 ghost effect

2.2.3 Advantages and Drawbacks

This approach simplifies the specification of feature correspondence over the mess warping but, it complicates warp generation. This is due to the fact that all line pairs must be considered before the mapping of each source point is known. This global algorithm is slower than mesh warping, which uses bi-cubic interpolation to determine the mapping of all points not lying on the mesh.[1] An optimization based on a piecewise linear approximation is offered by to accelerate the process. A more serious difficulty, though, is that unexpected displacements may be generated after the influence of all line pairs are considered at a single point. Additional line pairs must sometimes be supplied to counter the ill effects of a previous set. [3]

III. RULES FOR GOOD IMAGE MORPHING [5]

1. Attributes transformation;
2. Topology preservation;
3. Monotonicity;
4. Convexity preservation;
5. Feature preservation;
6. Smoothness preservation;
7. Non-linearity;
8. Use of transformation groups;
9. Slow-in and Slow-out;
10. Rigidity preservation;
11. Avoid morphing leakage.

IV. CONCLUSIONS

In conclusion, there are many methods that exist like: Thin Plate Splines, Energy Minimization, Multilevel Free-Form Deformation (MFFD) etc available. Among them this paper reviewed two techniques mesh warping and field morphing, with full description as available as possible. Field Morphing algorithms all share the following components: feature specification, warp generation, and transition control. The ease with which an artist can effectively use morphing tools is determined by the manner in which these components are addressed. The earliest morphing approach was based on mesh warping. It was motivated by a reasonably straightforward interface requiring meshes to mark features and bi-cubic spline interpolation to compute warp functions. Future morphing work includes further work in morphing among multiple images, and improving automatic morphing among a limited class of images and video sequences.

REFERENCES

[1] Seungyong Lee, George Wolberg and Kyung-Yong Chwa, “Image Metamorphosis with Scattered Feature Constraints”, IEEE TRANSACTIONS ON VISUALIZATION AND COMPUTER GRAPHICS, VOL. 2, NO. 4, DECEMBER 1996, pp 337-355.

[2] Md. Baharul Islam, Md. Tukhrejul Inam, and Balaji Kaliyaperumal, “Overview and Challenges of Different Image Morphing Algorithms”, International Journal of Advanced Research in Computer Science and Electronics Engineering (IJARCSEE) ISSN: 2277 – 9043, APRIL 2013, pp 410-414.

[3] George Wolberg, “Image morphing: a survey”, The Visual Computer (1998) 14:360-372 Springer-Verlag, 1998, pages 360-372.

[4] G. Wolberg, Digital Image Warping. Los Alamitos, Calif.: IEEE CS Press, 1990.

[5] Thaddeus Beier, Bruno Costa, Lucia Darsa and Luiz Velho “Warping and Morphing of Graphical Objects (SIGGRAPH)”, 1997

